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Description

[Underwater vacuum and sterilization system]

BACKGROUND OF INVENTION

[0001] 1. Field of the Invention The present invention relates to an underwater vacuum and sterilization system. More particularly, the invention relates to an underwater vacuum specifically designed for sterilizing and removing debris and potential bacterial film from large drinking water reservoirs, treatment and distribution facilities.

[0002] 2. Background and Description of the Related Art Protection of the public's health requires that potable water supplies be free of microorganisms that can cause health effects in humans. Also, supplies of potable water must be free from other contaminants that may taint the water and/or negatively impact its acceptability by the consumer, i.e. the members of the public. To ensure consistent and acceptable water quality, rules and regulations regarding testing, maintenance, and maximum tolerable

levels of contaminants for potable water reservoirs have been established. Disinfectant chemicals are used to destroy microorganisms in the water. However, it has been shown that sediment, which characteristically accumulates at the bottom of potable water reservoirs, insulates biological contaminants from the disinfection chemicals. Inspection of water storage tanks is recommended at least every five years. Many municipalities, which are charged with ensuring the quality of the water, opt to clean and inspect their reservoirs every year. This annual cleaning and inspection has traditionally been done by first draining the reservoir and then having teams of men physically enter the reservoir to clean and inspect it. This approach has many drawbacks, and some examples of these drawbacks are listed below. First, the procedure is wasteful of natural resources and is very costly. Second, the draining and filling of the reservoir can disturb the sediment, releasing biological contaminants into the pipes in the water distribution area served by that reservoir. Third, draining and filling a reservoir causes mechanical stress to the structure of the reservoir, which can lead to cracks in the reservoir structure. Fourth, the men entering the reservoir with their tools can cause damage to the protective finish

on the walls of the reservoir. Fifth, when a reservoir is drained there will usually not be an adequate supply of water to fight a major fire in the water distribution area served by the reservoir. To avoid the aforementioned drawbacks, the underwater vacuum and sterilization system of the present invention has been proposed. The underwater vacuum and sterilization system of the present is particularly adapted to ensure that the vacuum can sterilize all surfaces of a reservoir and remove sediment from the reservoir without causing turbidity in the water and thus avoiding the attendant introduction of biological contaminants into the water. Additionally the system is designed to sterilize all surfaces of a potable water reservoir without allowing any of the sterilization chemicals to enter the surrounding water column. The underwater vacuum of the present invention allows a team of divers to accomplish the cleaning and sterilization of a potable water reservoir without the drawbacks associated with the periodic emptying and filling of the reservoir. Although many underwater vacuum systems have been proposed in the art, none are seen to be specially adapted for the chemical sterilization and removal of sediment from potable water reservoirs while keeping any sterilization

chemicals, turbidity or biological contamination from being introduced into the water within the exacting requirements for potable water reservoirs. The following patents and other documents illustrate some examples of underwater vacuums that have been proposed in the underwater vacuum art.

[0003] U.S. Pat. No. 3,795,027, issued to Albert W. Lindberg, Jr. on Mar. 5, 1974, and U.S. Pat. No. 4,498,206, issued to Heinz W. Braukmann on Feb. 12, 1985, shows underwater vacuums having fixed brush bristles for cleaning swimming pools.

[0004] U.S. Pat. No. 5,404,607, issued to Pavel Sebor on Apr. 11, 1995, shows a self-propelled underwater vacuum for cleaning swimming pools. The Sebor device uses one or more pivotally mounted oscillators that are caused to oscillate by the flow of water through the vacuum, to cause the vacuum to move in a random path along the bottom of the swimming pool.

[0005] U.S. Pat. No. 5,412,826, issued to Dennis A. Raubenheimer on May 9, 1995, shows a self-propelled underwater vacuum for cleaning swimming pools. The Raubenheimer device uses a turbine driven by the flow of water through the suction cleaner to power a pair of wheels that

propel the vacuum.

[0006] U.S. Pat. No. 5,456,412, issued to Christopher J. Agee on October 10, 1995, shows a high-pressure surface-washing device. The Agee device is designed to be used in an air environment and will not work in an underwater environment. The Agee device does not have a vacuum system for removal of debris or fluid.

[0007] U.S. Pat. No. 5,617,600, issued to Ercole Frattini on Apr. 8, 1997, shows a self-propelled underwater vacuum for cleaning swimming pools. The Frattini device uses a submersible electric motor to drive a pump impeller to create suction and to drive a set of rollers to propel the underwater vacuum.

[0008] U.S. Pat. No. 6,081,960, issued to Forrest A. Shook, et al on Jul. 4, 2000, shows a high pressure cleaning and removal system for cleaning and removing coatings from building walls and floors or driveways, sidewalks, etc. The system works in an air environment and utilizes high-pressure fluid flow for cleaning and a high volume air vacuum to remove fluid and debris from inside a housing. The Shook system is designed for use in an air environment and will not work underwater on submerged surfaces.

[0009] U.S. Pat. No. 6,199,237, issued to Brent Budden on Mar. 13, 2001, shows an underwater vacuum with a turbine powered brush having an axis of rotation parallel to the surface being cleaned and having a unique structure of the suction head of the invention which allows vacuuming sediment without introducing turbidity, and the attendant biological contaminants, into potable water supplies. The Budden device does not sterilize surfaces cleaned. The Budden device does not use variable pressure fluid flow against surfaces for a cleaning method. The Budden device does not use a sterilization chemical or fluid flow of any kind. The Budden underwater vacuum uses only a rotating brush and water suction to clean reservoirs and claims that said rotating brush removes biofilm from potable water reservoir interior surfaces. It is my belief that a rotating brush and water suction alone will not remove all biofilm or bacterial contamination from potable water reservoir interior surfaces.

[0010] U.S. Pat. No. 6,378,163, issued to Frank J. Moll on Apr. 30, 2003, shows a high pressure cleaning and removal system for cleaning and removing coatings from building walls and floors or driveways, sidewalks, etc. The system works in an air environment and utilizes high-pressure fluid flow

for cleaning and a high volume air vacuum to remove fluid and debris from inside a housing. The Moll system is designed for use in an air environment and will not work underwater on submerged surfaces.

[0011] U.S. Pat. No. 6,413.323, issued to Forrest A. Shook, et al on Jul. 2, 2002, shows a high pressure cleaning and removal system for cleaning and removing coatings from building walls and floors or driveways, sidewalks, etc. The system works in an air environment and utilizes high-pressure fluid flow for cleaning and a high volume air vacuum to remove fluid and debris from inside a housing. The Shook system is designed for use in an air environment and will not work underwater on submerged surfaces.

[0012] U.S. Pat. No. 6,647,585, issued to Robert S. Robinson on Mar. 18, 2003 shows a high pressure cleaning and vacuum system for use on carpets. The system works in an air environment and is not designed for use underwater.

[0013] United Kingdom Complete Patent Specification Number 1,092,133, By Russell Edward Winn, published on Nov. 22, 1967, shows an underwater vacuum for cleaning the hulls of ships or inside storage tanks. The Winn device is a self-propelled vacuum with a steerable wheel and a pump for

creating suction. The Winn device also has two rotating brushes that rotate about axes perpendicular to the surface being cleaned. The Winn device is not concerned with the introduction of contaminants into the surrounding water column.

[0014] European Patent Application Number 468,876, By Michael John Chandler et al., published on Jan. 29, 1992, shows a self-propelled underwater vacuum which uses a turbine to power the drive wheels of the vacuum. The device of chandler et al. has fixed brush bristles.

[0015] None of the above inventions and patents, taken either singularly or in combination, is seen to describe the instant invention as claimed. In particular, none of the above inventions and patents disclose a means for sterilizing the surface being cleaned or the use of variable pressure fluid flow for removing debris or other matter from surfaces such as the present invention which allows vacuuming sediment without introducing turbidity, and the attendant biological contaminants, or sterilization chemicals, into potable water supplies.

Summary of Invention

[0016] The present invention is directed to an underwater or submersible vacuum and sterilization system including a

housing having an opening which, in use, is positioned adjacent the surface to be cleaned. The housing also supports a variable pressure sterilization and cleaning fluid flow mechanism, containment chamber, and a turbine. The housing has a water outlet which communicates with a pump at the surface of the water. The fluid flow mechanism communicates with a variable pressure pump at the surface of the water. The variable pressure pump is fluidly connected to a sterilization chemical and fluid source. There are many different types of sediment and materials that build up on potable water storage reservoir floors or other potable water treatment or distribution facilities. These materials may vary from easy to remove to sticky and difficult to remove. The amount of fluid pressure needed and the type of jet nozzle is dependendent on the job being done at the moment. Therefore the amount of fluid pressure may vary from a few hundred p.s.i. all the way up to 50,000 p.s.i. or more. The type of fluid jet nozzles used are also variable to the job at hand at the moment. None of the fluid pressure pumps or jet nozzles will be discussed in this patent due to the fact that they are readily available on the open market for purchase and are not the subject of this patent.

[0017] Water flowing through the vacuum is routed through the turbine. The inlet to the turbine has a trap which collects large debris that can damage the turbine blades. The flow of water through the turbine powers the rotation of the rear wheels so the vacuum is self-propelled over the surfaces being cleaned and sterilized. The vacuum has four wheels that support the vacuum and sterilization system adjacent the surface being cleaned while allowing free movement of the underwater vacuum over the surface. The two rear wheels are adjustably attached to the interior of the housing and connected by a shaft or axel, while the two front wheels are adjustably attached to the interior of the housing and are not connected by a shaft or axel. The particular arrangement and attachment of the wheels contributes to the capability of the underwater vacuum and sterilization system of the present invention to remove sediment from the bottom of a water storage reservoir without causing turbidity in the water column and propelling the vacuum over the surface being cleaned and sterilized. The structure and particular arrangement of the interior containment chamber effectively prevents any of the sterilization chemical fluid flow from entering and impacting the surrounding water column on the outside of

the vacuum housing.

[0018] A second embodiment has a rotable brush that is powered by the turbine powering the wheels. The rotable brush embodiment is used for cleaning water reservoirs with matter which is stubbornly attached to the surface being cleaned. This embodiment employs the rotable brush in combination with the variable pressure fluid flow mechanism for cleaning and sterilization.

[0019] A third embodiment is a handheld vacuum head with an enclosed variable pressure fluid flow mechanism. The handheld embodiment is used for cleaning and sterilizing surfaces that cannot be reached by the large powered embodiments.

[0020] Accordingly, it is a principal object of the invention to provide an underwater vacuum that can sterilize the interior surfaces of a water storage reservoir without causing turbidity or allowing sterilization chemicals in the water column.

[0021] It is another object of the invention to provide an underwater vacuum and sterilization system that can remove sediment from the bottom of a water storage reservoir without causing turbidity in the water column. It is another object of the invention to provide an underwater

vacuum and sterilization system having a variable pressure fluid flow mechanism to loosen sediment on the bottom of a water storage reservoir prior to the removal of the sediment by the suction of the vacuum.

[0022] It is a further object of the invention to provide an underwater vacuum and sterilization system having a turbine in the path of water flow through the vacuum such that the turbine can power the rotation of the wheels of the vacuum thereby causing it to be self-propelled.

[0023] It is a further object of the invention to provide an underwater vacuum and sterilization system having a turbine in the path of water flow through the vacuum such that the turbine can power the rotation of a brush used to loosen sediment, in combination with a variable pressure fluid flow mechanism, on the bottom of a water storage reservoir. Still another object of the invention is to provide an underwater vacuum and sterilization system having an internal containment chamber to prevent escape of any of the sterilization chemical into the surrounding water column on the exterior of the vacuum housing.

[0024] Still another object of the invention is to provide an adjustable means of supporting the internal containment chamber so the bottom opening is supported at the right

height and at the right angle above the surface to be cleaned so as to allow the surface to be sterilized without the generation of sterilization chemicals into the water column.

[0025] Still another object of the invention is to provide an underwater vacuum and sterilization system having wheels that are specially configured to support the vacuum above the surface to be cleaned such that the vacuum opening is supported at the right height and at the right angle above the surface to be cleaned so as to allow the surface to be cleaned without the generation of turbidity in the water column.

[0026] It is an object of the invention to provide improved elements and arrangements thereof for the purposes described which is inexpensive, dependable and fully effective in accomplishing its intended purposes. These and other objects of the present invention will become readily apparent upon further review of the following specification and drawings.

Brief Description of Drawings

[0027] FIG. 1 is an environmental view of an underwater vacuum and sterilization system according to the present invention being used by a diver.

[0028] FIG. 1a is an environmental view of an underwater vacuum and sterilization system according to the present invention (second embodiment with housing 23a) being used by a diver.

[0029] FIG. 2 is a cutaway perspective view of an underwater vacuum according to the present invention showing a variable pressure fluid flow mechanism with a plurality of pressure jets and a mechanism for providing power to the rear wheels.

[0030] FIG. 3 is a perspective view of an underwater vacuum according to the present invention.

[0031] FIG. 4 is a section view showing through the left side of the vacuum housing.

[0032] FIG. 5 is a cutaway section view showing through the front of the vacuum housing.

[0033] FIG. 6 is a bottom plan view of an underwater vacuum and sterilization system according to the present invention.

[0034] FIG. 7 is a perspective view of a second embodiment of an underwater vacuum and sterilization system.

[0035] FIG. 8 is a cutaway section view showing both a rotable brush and variable pressure fluid flow mechanism of a second embodiment of an underwater vacuum and sterilization system according to the present invention.

[0036] FIG. 9 is a cutaway perspective view of a second embodiment of an underwater vacuum and sterilization system showing the opening to the debris trap, the rotable brush, and the variable pressure fluid flow mechanism according to the present invention.

[0037] FIG. 10 is a cutaway perspective view of a second embodiment of an underwater vacuum and sterilization system showing the interior of the turbine and the drive linkage to the rotating brush, and the variable pressure fluid flow mechanism according to the present invention.

[0038] FIG. 11 is a top perspective of a second embodiment of an underwater vacuum and sterilization system showing the placement of exterior front wheels, placement of variable pressure fluid flow hose and different arrangement of vacuum housing front lower portion according to the present invention.

[0039] FIG. 12 is a bottom plan view of a second embodiment of an underwater vacuum and sterilization system showing the positioning of a rotable brush in combination with a variable pressure fluid flow mechanism according to the present invention. This variation of the underwater vacuum and sterilization system shows a low-pressure spray tube and would be used in situations where only steriliza-

tion is required from the variable pressure fluid flow mechanism due to the rotable brush being sufficient to remove the type of sediment in question.

[0040] FIG. 13 is a fragmentary view showing the height adjustment mechanism for the rear wheel shaft or axel or for the rotable brush of the underwater vacuum and sterilization system according to the present invention.

[0041] FIG. 14 is a fragmentary view showing the height adjustment mechanism for the non-powered wheels of the underwater vacuum and sterilization system according to the present invention.

[0042] FIG. 15 is an rear see-through plan view with phantom lines of a third embodiment of the underwater vacuum and sterilization system according to the present invention designed for use in cleaning the seam or joint where a wall meets the floor inside a potable water reservoir.

[0043] FIG. 16 is an side cut-away perspective view of a third embodiment of the underwater vacuum and sterilization system according to the present invention designed for use in cleaning the seam or joint where a wall meets the floor inside a potable water reservoir.

[0044] FIG. 17 is an rear cut-away perspective view of a fourth hand-held embodiment of the underwater vacuum and

sterilization system according to the present invention designed for use in cleaning small flat areas inside a potable water reservoir where the larger embodiments will not fit.

[0045] .FIG. 18 is a side see-through plan view with phantom lines showing a fifth embodiment of the underwater vacuum and sterilization system according to the present invention designed and used for cleaning and sterilizing the inside of pipes connected to a potable water reservoir.

[0046] FIG. 19 is a see-through perspective view of a fifth embodiment of the underwater vacuum and sterilization system with phantom lines inside the vacuum housing to reveal the variable pressure fluid flow mechanism and containment chamber for cleaning the outside of exposed pipes or roof support columns inside potable water reservoirs according to the present invention.

[0047] FIG. 20 is a top see-through plan view of a fifth embodiment of the underwater vacuum and sterilization system with the vacuum housing shown as transparent to reveal the internal variable pressure fluid flow mechanism and containment chamber for cleaning the outside of exposed pipes or roof support columns inside potable water reservoirs according to the present invention.

[0048] FIG. 21 is a side cut-away plan view of a fifth embodiment of the underwater vacuum and sterilization system to reveal the internal variable pressure fluid flow mechanism and containment chamber for cleaning the outside of exposed pipes or roof support columns inside potable water reservoirs according to the present invention.

[0049] FIG. 22 is an environmental perspective view of the main embodiment of the underwater vacuum and sterilization system to show how it is connected to a float on the surface of the water for the horizontal cleaning of potable reservoir walls according to the present invention.

[0050] Similar reference characters denote corresponding features consistently throughout the attached drawings

DETAILED DESCRIPTION

[0051] Referring to FIGS. 1-12, the present invention is an underwater vacuum 23 which includes a housing 24, a debris trap 25, a cylindrical turbine housing 26, turbines 28 and 30, a variable pressure fluid supply hose 33, a variable pressure fluid flow mechanism consisting of a fluid hose connector 35, vertical fluid flow delivery pipe 65, fluid flow system vertical height adjustment mechanism 47, vertical to horizontal fluid supply "T" fitting 49, horizontal fluid supply pipe 37, horizontal pipe to vertical

fluid supply threaded connectors 51, variable pressure fluid flow nozzles 53, an internal containment chamber consisting of a front wall 55, a right wall 57, a back wall 59, a left wall 61, the bottom of each wall having more than one flexible member, seal or plurality of bristles or brushes thereby defining a circumferential seal on the bottom edges, an open top 71, containment chamber adjustable vacuum housing attachment bolts or studs 39, vacuum housing adjustable attachment slots 43, containment chamber to vacuum housing attachment nuts 41, an optional rotating brush 32, front wheels 34 and 36, rear wheels 144, an outlet pipe 42, and a T-shaped handle 44. The housing 24 has a suction opening 46, a base portion 48, and a cap portion 50. The suction opening 46 is substantially rectangular. By substantially rectangular it is intended to convey that the opening 46 is generally rectangular and the perimeter may deviate from a perfect rectangle in that the opening 46 may have rounded corners or fillets at corners, or the opening 46 may have clearance channels (shown in FIG. 12) for the mounting hardware of the shaft of the rotating brush 32. The substantially rectangular perimeter of the suction opening 46 defines the plane of the suction opening. The suction opening 46 has

a rear edge 52, a front edge 54, a left edge 56, and a right edge 58.

[0052] There are two variations of the main embodiment vacuum. FIG. 1, 2, 3, 4, 5, 6, and 22 show vacuum 23 with vacuum housing 24. This embodiment employs the combination of water suction and variable pressure fluid flow for cleaning and sterilization. This embodiment does not utilize a rotable brush 32. The function of the vacuum housing 24 is the same as vacuum housing 24a, however the shape of the housing base portion 48 is different whereas the front wall is not curved where it extends from the suction opening front edge 54 to the front wall 62 of the cap portion 50.

[0053] The second embodiment shown in FIG. 1a, 7, 8, 9, 10, 11, and 12 show vacuum 23a with vacuum housing 24a. This embodiment employs the combination of water suction, variable pressure fluid flow, and a rotable brush for cleaning and sterilization. There are many types of sediment and/or matter that accumulate on the interior surfaces of potable water reservoirs. Depending on the type of material will vary the need of a rotable brush, the amount of fluid pressure utilized, or the sterilization needs. Due to the variety of needs for this process the vacuum 23 and

23a may need a combination of pressure fluid flow and a rotable brush or the use of pressure fluid flow without a rotable brush. The combinations of fluid flow and rotable brush may also have a varying need for the amount of pressure utilized in the fluid flow. The fluid flow has two purposes; one is to sterilize the surface being cleaned and the other is to use the pressure fluid flow to remove material from the surface being cleaned. On the extreme high pressure end of the spectrum the fluid flow may be utilized to even remove paint, epoxy, or other coatings from steel surfaces. On the low end of the pressure spectrum the fluid flow may only be a low-pressure spray (as shown in FIG. 12 lateral water pipe 37). The latter embodiment only needs low-pressure spray to sterilize the surface, which has been adequately cleaned by the rotable brush 32. Another difference between vacuum 23 and 23a is that vacuum housing 24a does not need power to drive the rear wheels due to the fact that the rotable brush 32 propels the vacuum.

[0054] Referring to vacuum 23a and vacuum housing 24a, the cap portion 50 has a rear wall 60 and a front wall 62, which is spaced apart from the rear wall 60. The cross sectional area, in a plane parallel to the plane of the suc-

tion opening 46, of the cap portion 50 tapers from a maximum where the cap portion 50 joins the base portion 48 to a minimum at the cap portion top 64. The front wall of the base portion 48 is curved or rounded and it extends from the suction opening front edge 54 to the front wall 62 of the cap portion 50. The front wall of the base portion 48, or a portion thereof, follows or parallels the contour of a cylindrical surface defined by the tips of the bristles of the brush 32. The rear wall of the base portion 48 extends, perpendicular to the plane of the suction opening 46, from the suction opening rear edge 52 to the rear wall 60 of the cap portion 50. The base portion 48 has a right sidewall 66 and a left sidewall 68.

[0055] The right sidewall 66 is joined to the rear wall of the base portion 48 along substantially the entire length of the right edge of the rear wall of the base portion 48. The top edge of the right sidewall 66 is joined to the cap portion 50 along substantially the entire length of the right edge of the widest portion of the cap portion 50. The right sidewall 66 is joined to the front wall of the base portion 48 along substantially the entire length of the curved right edge of the front wall of the base portion 48. The bottom edge of the right sidewall 66 essentially forms the right

edge 58 of the suction opening 46.

[0056] The left sidewall 68 is joined to the rear wall of the base portion 48 along substantially the entire length of the left edge of the rear wall of the base portion 48. The top edge of the left sidewall 68 is joined to the cap portion 50 along substantially the entire length of the left edge of the widest portion of the cap portion 50. The left sidewall 68 is joined to the front wall of the base portion 48 along substantially the entire length of the curved left edge of the front wall of the base portion 48. The bottom edge of the left sidewall 68 essentially forms the left edge 56 of the suction opening 46. The front and rear walls of the base portion 48, the left sidewall 68, the right sidewall 66, and the cap portion 50 cooperatively form an enclosure or concavity which opens to the suction opening 46.

[0057] The brush 32 is rotatably supported intermediate the left sidewall 68 and the right sidewall 66. The brush 32 is oriented such that it axis of rotation is parallel to the plane of the suction opening 46. The brush 32 has a central shaft 70 each end of which is journaled in mounting hardware attached to a respective one of the left and right sidewalls 68 and 66. The details of the mounting hardware will be discussed later. The bristles of the brush 32

may have their roots embedded directly in the shaft 70 or, alternatively, the roots of the sleeves may be embedded in a cylindrical sleeve which is keyed or otherwise fixed to the shaft 70. Most preferably, the roots of the bristles of each half of the brush 32 are embedded over a helical strip into either the sleeve or the shaft 70. The helical strips over which the bristles are embedded are angled in opposite directions for each half of the brush 32 such that the bristles on each half of the brush 32 act as screw conveyors moving the sediment toward the center of the suction opening 46 where it can be vacuumed up more readily and with a lesser chance of escaping to the outside of the housing 24a.

[0058] Referring to FIG. 8, the brush 32 is powered to rotate such that the bristles of the brush 32 move toward the rear of the housing 24a as the bristles pass under the axis of rotation of the brush 32. This means that with the underwater vacuum 23a oriented as illustrated in FIG. 8, the brush 32 is powered to rotate in the clockwise direction. For the helically arranged bristles to push sediment toward the center of the housing 24a, the bristles on the right half of the brush 32 are arranged along a helical strip having an acute helix angle when measured from the inside surface

of the right sidewall 66 in a clockwise direction. Also, the bristles on the left half of the brush 32 are arranged along a helical strip having an acute helix angle when measured from the inside surface of the left sidewall 68 in a counter clockwise direction, as illustrated in FIG. 12.

[0059] The brush 32 is positioned within the housing 24a such that the bristles of the brush project for a user determined distance beyond the plane of the suction opening 46. The brush 32 has soft bristles so as not to damage the surface coatings of the water reservoir being cleaned. In addition, a flange 74 projects from about the suction opening 46. A soft bumper 76 made of a rubber or plastic material covers the flange 74. The bumper 76 provides further protection against damage to the surfaces of the reservoir being cleaned due to being bumped by the housing 24a.

[0060] The front wheels 34 and 36 are attached to the outer surface of the front most portion of the front wall of the base portion 48 of the housing 24a. The rear wheels 38 and 40 are attached to the outer surface of the rear wall of the base portion 48 of the housing 24a (as shown in FIG. 8). The wheels 34, 36, 38, and 40 are attached at their respective locations in such a way that they can all rotate freely. The wheels 34, 36, 38, and 40 support the housing

24A at a user selected height above the surface of the reservoir that is being cleaned, and these wheels allow the underwater vacuum 23a to be pushed along the surface being cleaned. The details of the attachment of the wheels 34, 36, 38, and 40 are discussed later.

[0061] An opening 78 is provided in the front wall 62 of the cap portion 50 of the housing 24 and 24a. A reinforcing bar 77 extends between the front and rear walls of the base portion 48. The reinforcing bar 77 helps keep the rear wall, formed by the rear walls of the base portion 48 and the cap portion 50, of the housing 22 from collapsing under the pressure differential between the exterior and the interior of the housing 22. The opening 78 communicates with the debris trap 24. The debris trap 24 is formed by three walls, two of which project perpendicularly from the front wall 62 on either side of the opening 78. The third wall forming the debris trap 24 extends between the edges, located distal from the front wall 62, of the two walls, which project from the front wall 62. The walls forming the debris trap 24 also join the top surface of the curved front wall of the base portion 48. Thus, the top surface of the curved front wall of the base portion 48 forms the bottom of the debris trap 24. The open top 80

of the debris trap 24 is provided with a hinged closure 82 which can be secured in the closed position by the latch 84.

[0062] In the illustrated example, the latch 84 is in the form of a hook that is engageable with an eye 86; however, the latch 84 may be of any known type. A sealing strip or gasket (not shown) may be provided about the perimeter of the closure 82 to provide a watertight seal about the open top 80 of the debris trap 24. To maximize water flow through the housing 24 and 24a, an essential feature for eliminating turbidity, the opening 78 should be made as large as possible. Most preferably, the opening 78 has a width approximately equal to the distance between the interior surfaces of the right and left walls of the debris trap 24 and a height approximately equal to the distance between the top 64 of the cap portion 50 and the top edge of the front wall of the base portion 48.

[0063] The cylindrical turbine housing 26 is fixed to the right wall of the debris trap 24. The right wall of the debris trap 24 has a hole 88 with a diameter essentially equal to the inside diameter of the cylindrical turbine housing 26. The hole 88 allows fluid communication between the interior of the debris trap 24 and the interior of the turbine hous-

ing 26. Spokes 90 concentrically support a bearing 92, which rotatably supports an end of the turbine shaft 94. The turbine shaft 94 extends through the closed end of the turbine housing 26 such that the end of the shaft 94 distal from the bearing 92 lies outside the turbine housing 26. The portion of the shaft 94 passing through the closed end of the turbine housing 26 is journaled within a bearing surface formed in the closed end of the turbine housing 26, such that the shaft 94 can rotate freely.

[0064] Spokes 90, in addition to supporting the bearing 92, act as a screen to keep debris that may damage the blades of turbines 28 and 30 from entering the turbine housing 26. Where relatively smaller particles or debris cause concern relating to possible damage to the blades of the turbines 28 and 30, a wire mesh screen may be provided at the opening 88. Debris trapped in the debris trap 24 can be removed through the hinged closure 82.

[0065] A sprocket 96 is fixedly attached to the end of the shaft 94, which is outside the turbine housing 26. A chain 98 engages the sprocket 96 and a sprocket 100 which is fixedly attached to the shaft 70 (vacuum 23a and vacuum housing 24a) or a sprocket 146, which is fixedly attached to the rear wheel shaft 142 (vacuum 23 and vacuum

housing 24). Thus, rotation of the turbine shaft 94 causes the rotation of the brush shaft 70 in vacuum 23a or the rear wheel shaft 142 in vacuum 23. The chain 98 passes through holes 102 formed in the upper portion of the front wall of the base portion 48. The chain 98 is in the form of an endless loop.

[0066] Any suitable power transmission mechanism may be substituted for the chain 98 and the sprockets 96 and 100 without departing from the spirit and scope of the present invention. For example, a belt and pulley can be used in place of the chain 98 and the sprockets 96, 100, and 146, or the shaft 70 or shaft 142 can be extended to the exterior of the housing 24 or 24a and a fully enclosed gear train used transmit power from an extended shaft 94 to the shaft 70 or 142.

[0067] The turbines 28 and 30 are of the axial flow type and are positioned in tandem within the turbine housing 26. The blades of each of the turbines 28 and 30 are fixed to the common turbine shaft 94 such that the turbine blades and the shaft 94 rotate together. Thus, water flow past the blades of the turbines 28 and 30 powers the rotation of the shaft 94 and in turn, through the use of the belt 98, the rotation of the brush 32.

[0068] As water passes through the upstream turbine 28 and rotating current is generated in the water flowing through the turbine housing 26. This rotating current causes the downstream turbine 30 to lose effectiveness. To remedy this problem, re-directional baffles 112 are provided intermediate the turbines 28 and 30. The baffles 112 are fixed to the inside surface of the cylindrical wall of the turbine housing 26 and extend radially inward toward the shaft 94, but the baffles 112 do not touch the shaft 94 so as not to interfere with the rotation of the shaft 94. The baffles 112 straighten out the flow of the water, i.e. restore the flow to purely axial flow as much as possible, before the water impinges upon the blades of the downstream turbine 30 to thereby restore efficiency to the downstream turbine 30 and thus increase the combined power output from the turbines 28 and 30.

[0069] Any motor mechanism may be substituted for turbine housing 26 and turbines 28 and 30 without departing from the spirit and scope of the present invention. For example a water powered vane type side driving motor, submersible electric motor or air pressure motor can be substituted in place of turbine housing 26 and turbines 28 and 30. The motor mechanism only supplies power to

drive the rear wheels and/or rotable brush of the present invention and does not deviate from the principle of a combination variable pressure fluid flow, water suction and / or rotable brush for the cleaning and sterilization of underwater surfaces.

[0070] The outlet of the turbine housing 26 is positioned intermediate the downstream turbine 30 and the closed end of the turbine housing 26. The outlet of the turbine housing 26 communicates with the outlet pipe 42. The inlet of the outlet pipe 42 is rigidly fixed about the outlet of the turbine housing 26. The outlet pipe 42 extends directly rearward from the turbine housing 26 until the outlet pipe 42 clears the rear wall of the cap portion 50 of the vacuum housing 24 or 24a. Once clear of the rear wall of the cap portion 50 of the vacuum housing 24 or 24a, the outlet pipe 42 makes a first bend. The outlet pipe 42 extends, parallel to the plane of the suction opening 46, from the first bend toward the middle of the housing 24 or 24a. Once near the middle portion of the housing 24 or 24a, i.e. near the portion of the rear wall 60 extending downward from the top 64 of the cap portion 50, the outlet pipe 42 makes a second bend and extends upward perpendicular to the plane of the suction opening 46. The

outlet pipe 42 terminates in a coupling 104 that allows the outlet pipe 104 to be connected to a flexible pipe 106 which is in turn connected to a pump (not shown) at the surface. A support plate 108 is rigidly fixed to the front wall 62 of the cap portion 50. The outlet pipe 42 passes through the support plate 108 near the joint between the turbine housing 26 and the outlet pipe 42. Thus the support plate 108 supports the inlet to the outlet pipe 42, and the support plate 108 also supports the closed end of the turbine housing 26 via the inlet to the outlet pipe 42.

[0071] A socket 110 is pivotally attached to the rear wall, formed by the rear walls of the base portion 48 and of the cap portion 50, of the housing 24 or 24a. The socket 110 allows the attachment of the T-shaped handle 44. The user can fix the angle of the socket 110 relative to the rear wall of the base portion 48 at any desired angle. The fixing of the socket angle can, for example, be accomplished frictionally by tightening a nut and bolt passing through the pivot point of the socket 110.

[0072] In use, the underwater vacuum 23 or 23a is placed on the bottom surface of a potable water reservoir such that it is supported over the bottom of the reservoir by the four wheels 34, 36, 144 and 144 (underwater vacuum 23) or

four wheels 34, 36, 38, and 40 (underwater vacuum 23a). When the vacuum 23 or 23a is thus positioned, the suction opening will be positioned adjacent the surface to be cleaned. The flexible pipe 106 connects the outlet pipe 42 to a pump located above the surface of the water in the reservoir. Such pumps are well known and are therefore not described here. A diver then stands behind the vacuum 23 or 23a and grasps the T-shaped handle 44. The pump is now turned on, causing water to be drawn through the suction opening 46, through the housing 24 or 24a, and up the flexible pipe 106. The diver then walks behind the vacuum 23 or 23a, and the vacuum 23 or 23a moves self-propelled along the bottom of the reservoir, to apply the cleaning and sterilization action of the vacuum 23 or 23 a to an increasingly wider area of the reservoir bottom.

[0073] Due to the suction created by the pump, water rushes into the housing 24 or 24 a through the suction opening 46. The water moves at a high flow rate up the cap portion 50 of the housing 22. The water then passes through the opening 78 and into the debris trap 24. From the debris trap 24 the water rushes through the turbine housing 26, through the outlet pipe 42, and up the hose 106 to the

surface. As the water rushes through the turbine housing 26, the axial flow turbines 28 and 30 and the shaft 94 are caused to rotate or spin. The rotating shaft 94 causes the rotation of the shaft 70 or shaft 142 via the sprockets 96, 100 and/or 146 and the chain 98. The brush 32, being fixed to the shaft 70, or the rear wheels 144, being fixed to the shaft 142, are set in motion rotating about the longitudinal axis of the shaft 70 (vacuum 23a) or the shaft 142 (vacuum 23). The rotating brush 32 scrubs the reservoir bottom dislodging the sediment film coating the reservoir bottom. The dislodged sediment and the biological contaminants contained in it are carried, by the water rushing through the housing 24a, up the hose 106 and to the surface where the water containing the sediment is discarded in accordance with applicable regulations. This process continues as long as the pump is turned on. Thus, the removal of the sediment and associated biofilm, from the bottom of the reservoir is effected without introducing turbidity into the reservoir water. Simultaneously the variable fluid flow mechanism via vertical fluid flow pipe 65 and connectors 51 and 49 and horizontal fluid flow pipe 37 to fluid flow nozzles 53 introduces fluid sterilization chemical against the surface of the bottom of the reser-

voir behind the rotable brush 32 to remove any additional stubborn biofilm and sterilize said surface.

[0074] Note the sterilization chemicals used are 200 ppm chlorine solution or of a type similar to 200 ppm chlorine solution which is accepted as "instant kill" for microorganisms and need only touch the surface momentarily for effective sterilization. In vacuum 23 the fluid flow may be of high pressure and the fluid chemical sterilization solution is from entering the surrounding water column outside of vacuum housing 24 by means of the bottom sealed internal containment chamber walls 55, 57, 59, and 61 and bottom circumferential seal 63. The volume of fluid flow via the fluid flow mechanism is significantly less (between 6 and 60 gpm) than the water suction exiting the vacuum housing 24 or 24a via the outlet pipe 42 and flexible suction pipe 106 (which normally ranges between 150 and 300 gpm). Thus the open top of the containment chamber 71 allows for the greater suction through outlet pipe 42 and flexible suction pipe 106 to effectively and instantly remove all variable pressure fluid flow and sterilization chemical from the vacuum housing 24 or 24a and therefore avoid any introduction of the sterilization chemical into the water column on the outside of vacuum housing

24 or 24a. Simultaneously the variable pressure fluid flow cannot exit the suction opening 46 and cause turbidity on the outside of vacuum housing 24 or 24a.

[0075] It is important to note that the internal containment chamber is a necessary and integral part of the present invention. If the circumferential seal were placed around the suction opening 46 it would provide the same function of preventing turbidity from the variable pressure fluid flow and would prevent the escape of sterilization chemical into the surrounding water column. However, if the circumferential seal were placed around the suction opening 46 the vacuum housing 24 or 24a would suck down against the reservoir surface and would not be moveable along the surface being cleaned and sterilized.

[0076] Referring to FIG. 14, a height adjustable attachment for the wheels 34, 36, 38, and 40 can be seen. Wheel 36 is being used as representative of all the wheels 34, 36, 38, and 40. A pair of parallel plates 114 are fixedly attached to the housing 24 or 24a. In the case of the wheels 34 and 36 the plates 114 would be attached to the front wall of the base portion 48, while in the case of the wheels 38 and 40 the plates 114 would be attached to the rear wall of the base portion 48. Each plate 114 has an elongated

slot 116. The slots 116 are in registry with one another. The slots 116 are just wide enough for the threaded shaft of the bolt 118 to pass through the slots 116. The length of the slots 116 provides the range of adjustment of the position of the wheel 36 in a direction perpendicular to the plane of the suction opening 46.

[0077] The wheel 36 is rotatably supported by the bushing 120 which is slightly longer than the wheel 36 is wide. The plates 114 are spaced apart to allow the bushing 120 to fit therebetween. When the bushing 120 is placed between the plates 114, the central bore of the bushing 120 can be brought into registry with the slots 116. The inside diameter of the bushing 120 is about the same as the width of the slots 116. The outside diameter of the bushing 120 is greater than the width of the slots 116. With the bushing 120 placed through the central hole 122 of the wheel 36, the bushing 120 is then placed between the plates 114 with the central bore of the bushing 120 in registry with the slots 116. The bolt 118 is then passed through the slots 116 and the bushing 120, and the nut 124 is threadedly engaged to the end, distal from the bolt head, of the bolt 118. The wheel 36 is then moved to the desired position along the slots 116 and the nut 124 is tightened to

frictionally secure the wheel 36 in place while allowing free rotation of the wheel 36.

[0078] Referring to FIG. 13, a height adjustable attachment for the shaft 70 or shaft 142 can be seen. Each end of the shaft 70 or shaft 142 is journaled within the central boss or cylindrical portion 126 of the mounting attachments 128. The mounting attachments 128 have lateral extensions 130 which are provided with bolt holes 132. The bolt holes 132 are in registry with elongated slots 136. A pair of slots 132 is formed in each of the side walls 66 and 68 for the shaft 70 or shaft 142. Only the attachment of the right end of the shaft 70 or shaft 142 is shown in detail, the attachment of the left end of the shaft 70 or shaft 142 being a mirror image of the right end. Each one of a pair of bolts 134 pass s through a respective bolt hole 132 and a respective slot 136. The slots 136 are just wide enough for the threaded shaft of the bolt 134 to pass through the slots 136. The length of the slots 136 provides the range of adjustment of the position of the shaft 70 or shaft 142 in a direction perpendicular to the plane of the suction opening 46.

[0079] Each one of a pair of nuts 138 is threadedly engaged to the end, distal from the bolt head, of a respective one of

the bolts 134. The ends of the shaft 70 or shaft 142 are then moved to the desired position along the slots 136 and the nuts 138 are tightened to friction ally secure the shaft 70 or shaft 142 in place. The chain 98 is sized to remain under tension, and in frictional engagement with sprockets 96, 100, and 146, over the entire adjustment range of the shaft 70 or shaft 142. The adjustable attachments of the wheels 34, 36, 38, and 40 and of the shaft 70 or shaft 142 allow the underwater vacuum to be adjusted for sediment accumulations having varying depths.

[0080] Referring to FIGS. 15 and 16, a third handheld or manually pushed embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The manual underwater vacuum 23b is designed for cleaning and sterilizing the area where reservoir walls meet the floor. The larger vacuum"s 23 or 23a cannot reach this wall to floor joint or seam. The vacuum 23b differs from the vacuum 23 and 23a in the fact that it is not self-propelled and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in combination with water suction. The vacuum 23b also has an internal containment chamber similar to vacuum 23. Vacuum 23b has two suc-

tion openings 46 and two containment chamber seal areas 158. Each of the respective two openings has a specific purpose of adjacent plane contact with the wall on the vertical side and the floor on the horizontal side for cleaning and sterilizing the area near and where the wall and floor meet. There are four wheels 156 attached to the bottom of the vacuum housing 24b which make contact with the reservoir floor 182. The height of the wheels is adjustable to allow for the optimum water flow between the floor and housing. There are two wheels 156 adjustably attached to the vertical portion of the vacuum housing 24b which maintain the proper horizontal distance between the vacuum housing and the wall 180. The fluid hose 33 is attached to the fluid flow internal tube 155 by means of attachment 35. The fluid flow nozzle or jet 53 is threadedly attached to the end of fluid flow tube 155. The fluid flow nozzle shown in this figure is a rotating pressure turbo jet nozzle that spins in order for the fluid jet to spray all surfaces exposed under the vacuum housing 24b. The variable pressure fluid flow nozzle can be of a variety of types such as a fan spray nozzle or multiple low-pressure spray nozzles. The internal containment chamber 73 is open on the upper portion 71 to al-

low for water flow to travel from the inside of the containment chamber 73 as well as around the exterior space between the containment chamber 73 and the vacuum housing 24 b. The bottom of the containment chamber has a circumferential flexible seal 158, which prevents the variable pressure fluid flow from escaping to the exterior of the vacuum housing 24b. As in other embodiments this device has a water suction flexible pipe 106, which is connected to a water pump on the exterior of the reservoir which is connected to the outlet pipe 42 by means of attachment 104. The variable pressure fluid hose 33 is connected to a variable pressure fluid pump on the exterior of the reservoir.

[0081] Referring to FIG. 17, a fourth handheld embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The handheld underwater vacuum 23c is designed for cleaning smaller flat areas where the vacuums 23, 23a, or 23b cannot reach. The vacuum 23c differs from the vacuum 23, 23a and 23b in the fact that it is not self-propelled and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in combination with water suction. The vacuum 23c also has

an internal containment chamber similar to vacuum 23. Vacuum 23c only has one suction opening 46 whereas vacuum 23b has two suction openings 46, one for the wall and one for the floor. The vacuum 23c has a manual trigger 164 for operating the variable pressure fluid flow mechanism, which is an optional element of vacuums 23, 23a, and 23b. This device has two handles 166 for manual operation. Like the other embodiments a water suction flexible pipe 106 is attached to an outlet pipe 42 by means of an attachment collar 104. This flexible pipe 106 is connected to a water pump on the exterior of the reservoir. The variable pressure fluid flow mechanism is connected to a variable pressure fluid pump on the exterior of the reservoir by means of a water hose 33. The water hose is connected to an internal fluid transmission pipe 155, which is connected to a variable pressure fluid nozzle 53. As in other embodiments the type of fluid flow nozzles can vary from a high pressure rotating nozzle to a fan spray nozzle of multiple low-pressure nozzles. The internal containment chamber 73 is attached to the vacuum housing 24c by means of attachment bars 168. The containment chamber has openings 160 that allow the water to flow from the inside of the containment chamber

as well as from the space between the containment chamber 73 and the vacuum housing 24c. The water flows by way of suction out through outlet pipe 42 to the flexible pipe 106. The lower circumference of the internal containment chamber 73 has a flexible seal 158 to prevent the variable pressure fluid flow from escaping to the exterior of vacuum housing 24c. The lower circumference of the vacuum housing 24c has openings as shown in expanded view 162. These openings allow for water flow to the inside of the vacuum housing to prevent the opening 46 from sucking down and sticking to the surface being cleaned and sterilized.

[0082] Referring to FIG. 18, a fifth self-propelled embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The self-propelled underwater vacuum 23d is designed for cleaning the interior portions of pipes connected to potable water reservoirs where the vacuums 23, 23a, 23b or 23c cannot reach. The vacuum 23d differs from the vacuum 23, 23a, 23b and 23c in the fact that it is not self-propelled by wheels or a rotable brush and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in com-

bination with water suction. The vacuum 23d does not have an internal containment chamber similar to vacuum 23, 23b, or 23c. Vacuum 23d only has one suction opening 46 whereas vacuum 23b has two suction openings 46, one for the wall and one for the floor. The vacuum 23d is self-propelled by the backward direction of the variable pressure fluid flow against the interior surface of the pipe. The fluid flow mechanism turbo jet nozzle spins to clean all interior surface of pipes and by virtue of a backward direction of the fluid flow the device is self-propelled. The technology of this type of turbo rotating jet nozzle is not the subject of this invention and is available on the open market from a variety of manufacturers. The prior art of this fluid flow pressure nozzle system is widely used for cleaning sewer pipes in the utility industry. The difference between the present invention and prior art sewer cleaning technology is that this invention combines water suction to remove debris loosened by the fluid flow jet nozzle. There is no need for a internal containment chamber due to the fact that all sterilization chemical and debris loosened by the fluid flow jet is directed back towards the vacuum suction opening 46 and all materials are rapidly removed from the confined enclosed space between the

vacuum housing 24d and the interior walls of the pipe. The device has six wheels 170 that are attached to a bar 172 that is adjustably attached to the vacuum housing 24d by means of moveable arms 173. The three adjustable wheel assemblies (only two are shown) maintain the vacuum 23d in a center position inside the pipe equal distant from the interior pipe surface 178. The vacuum housing 24d and outlet pipe 42, in this embodiment, serve the same purpose. The outlet pipe 42 is attached to the flexible suction pipe 106 by means of attachment collar 104. The flexible suction pipe 106 is connected to a water pump on the exterior of the reservoir. This embodiment can be used for cleaning and sterilizing the interior of any pipe whether attached to a water reservoir or not.

[0083] Referring to FIGS. 19, 20 and 21, a sixth float driven embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The circular underwater vacuum 23e is designed for cleaning the exterior surfaces of roof support columns and/or exposed internal pipes where the vacuums 23, 23a, 23b, 23c or 23d can not reach. This embodiment can also be fabricated in a rectangular, square or other design for square, rectangular, or other shaped roof support

columns. The vacuum 23e differs from the vacuum 23, 23a, 23b, 23c or 23d in the fact that it is not self-propelled and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in combination with water suction. The vacuum 23e also has an internal containment chamber 73 with an open top 71 similar to vacuum 23. Vacuum 23e only has one suction opening 46 whereas vacuum 23b has two suction openings 46, one for the wall and one for the floor. The vacuum 23e has a circumferential suction opening 46 that surrounds a cylindrical column or pipe. The vacuum 23e can also be adapted to surround a rectangular or other shaped column. The vacuum 23e is propelled in an upward direction by means of air-activated floats (not shown in drawings). The internal containment chamber 73 has an internal circumferential flexible seal 158 similar to the other embodiments to prevent escape of the variable pressure fluid flow to the exterior of vacuum housing 24e. The variable pressure fluid flow mechanism has a plurality of variable pressure fluid flow nozzles 53 arranged in around the interior circumference of the containment chamber 73. The fluid flow nozzles are connected by means of threaded attachments 35 to short

sections of high-pressure fluid hose 33. The fluid hose 33 is flexible allowing for the circular arrangement of the fluid flow nozzles 53. The vacuum housing 24e and internal containment chamber 73 are flexibly attached by means of hinge 186 to allow for the device to open so it can be placed around the internal column. The hinged portions of the housing and internal chamber are held closed by means of a latch 187. In order to open the circular arrangement of fluid nozzles and fluid hose to place the device around a column the fluid hose attachment 35 nearest the latch 187 is detached and then re-attached prior to closing the latch 187. A plurality of wheels 192 have a shaft 188 that is adjustably attached to the internal circumference of the vacuum housing 24e. Each wheel is place and attached inside a slot 190 on the internal circumference of the vacuum housing 24e. As in the other embodiments the flexible water suction pipe 106 is connected to a water pump on the exterior of the reservoir. The water pipe is attached to the outlet pipe 42 by means of attachment collar 104. The outlet pipe 42 is fixedly attached to the vacuum housing 24e. The internal containment chamber 731 is fixedly attached to the inside of the vacuum housing 24e by means of a plurality of attach-

ment bars 168. The high-pressure fluid hose 33 is attached to the fluid flow mechanism by means of attachment 35 and fluid pipe 65 and housing attachment 51. The fluid flow pipe is attached to the fluid flow mechanism by means of a "T" fitting 49. The outside perimeter of the internal containment chamber 73 is open 71. The outside perimeter of the internal containment chamber has bars 194 that connect the top and bottom walls of the chamber together. The open outside perimeter 71 of the internal containment chamber 73 allows for water flow to the outlet pipe 42 from the inside of the internal containment chamber 73 as well as from the space surrounding the internal containment chamber between it"s top and bottom walls and the walls of the vacuum housing 24e.

[0084] Referring to FIG. 22, a seventh float controlled embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. This embodiment utilizes vacuum 23 or 23a for cleaning and sterilizing walls or other vertical flat surfaces inside water reservoirs or other water facilities. The only difference between this embodiment and vacuums 23 and 23a is the fact that it"s vertical position relative to the floor 208 or surface of the water 206 is maintained by a

cable 200 attached to a float 202 at the water surface 206. The vacuum is held to the wall 204 surface by water suction and is self-propelled in a horizontal direction by it"s motor and drive mechanism as previously described. After the vacuum makes a complete circumference of the reservoir it is turned in the opposite direction and raised a distance equal to one width of the vacuum suction opening 46. The vacuum is raised by turning a small winch 198 by hand which is fixedly attached to the vacuum housing cap 50 by a winch attachment 210. This process is repeated successively cleaning and sterilizing a complete circumference or perimeter of the reservoir until the entire vertical surface is cleaned and sterilized.

[0085] It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims. The basis of this invention is to cover any combination of water suction, variable pressure fluid flow, and rotable brush for the cleaning and sterilization of underwater surfaces.